Review Paper

Int. J. on Recent Trends in Engineering and Technology, Vol. 8, No. 2, Jan 2013

Power Quality Parameters Measurement Techniques

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Abstract: **Power quality (PQ) issue has attained considerable attention in the last decade due to large penetration of power electronics based loads and/or microprocessor based controlled loads. On one hand these devices introduce power quality problem and on other hand these mal-operate due to the induced power quality problems. PQ disturbances/events cover a broad frequency range with significantly different magnitude variations and can be non-stationary, thus, accurate techniques are required to identify and classify these events/disturbances. This paper presents a comprehensive overview of different techniques used for PQ events' classifications, parameters. Various artificial intelligent techniques which are used in PQ event classification are also discussed. Major Key issues and challenges in classifying PQ events are critically examined and outlined. In this paper, the main Power Quality (PQ) problems are presented with their associated causes and consequences. The economic impacts associated with PQ are characterized. Finally, some solutions to mitigate the PQ problems are presented.**

Key words:- **Power Quality, disturbances, PQ parameters.**

I. Introduction

One of the fundamental challenges facing utility and power customer personnel is the need to become familiar with and stay informed about issues dealing with power quality. As the utility industry undergoes restructuring and as customers find their service needs changing with increased use of equipment and processes more susceptible to power system disturbances, power suppliers and customers alike will find a solid background in power quality not only useful, but also necessary for continued productivity and competitiveness. Electrical Power quality is a term which has captured increasing attention in power engineering in the recent years. Even though this subject has always been of interest to power engineers, it has assumed considerable interest in the 1990's. Electric power quality means different things for different people. Classification of power quality areas may be made according to the source of the problem such as converters, magnetic circuit non linearity, arc furnace or by the wave shape of the signal such as harmonics, flicker or by the frequency spectrum (radio frequency interference). The wave shape phenomena associated with power quality may be characterized into synchronous and non synchronous phenomena. Synchronous phenomena refer to those in synchronism with A.C waveform at power frequency. Along with technology advance, the organization of the worldwide economy has evolved towards globalization and the profit margins of many activities tend to decrease.

A. Power Quality Characterization

Even the most advanced transmission and distribution systems are not able to provide electrical energy with the desired level of reliability for the proper functioning of the loads in modern society[1]. Even with a 99,99% level there is an equivalent interruption time of 52 minutes per year. The most demanding processes in the modern digital economy need electrical energy with 99.9999999% availability (9-nines reliability) to function properly. Between 1992 and 1997, EPRI carried out a study in the US to characterize the average duration of disturbances[2].

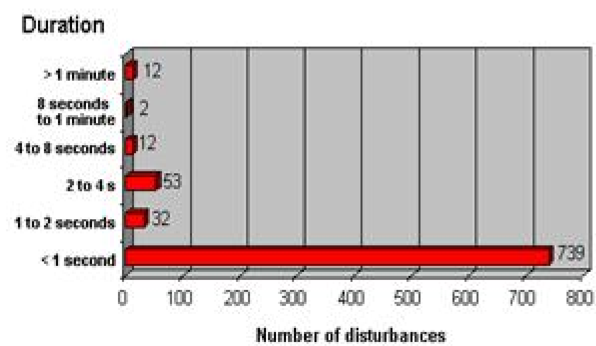

Fig. 1– Typical distribution of PQ disturbances by its duration for a typical facility in 6 years (1992-97)

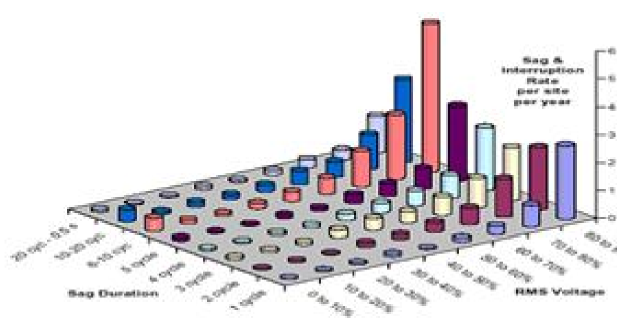

Fig-2-Comparative studies of various disturbances

92% of PQ disturbances were voltage sags with amplitude drops up to 50% and duration below 2 seconds[3].

B. Measures of Electric Power Quality

1. Total Harmonic Distortion (THD)

For a periodic wave, THD is defined as:

i = order of harmonics.

V(i) = Amplitude of ith harmonic component of voltage

DOI: 01.IJRTET.8.2.541

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$$THD = \frac{\sqrt{\sum_{i=2}^{1=\infty} V^{(i)^2}}}{V^{(1)}} \qquad (1)$$

2. Telephone Influence Factor (TIF)

Wis (weights) reflect the response of human ear. The infinite sum is truncated for practical use. (Say to 5kHz as per ANSI Standard 368). [4]The TIF is usually applied to line currents since the nature of Electromagnetic induction is related to line current amplitude.

3. V.T Product

$$TIF = \frac{\sqrt{\sum_{i=2}^{1=\infty} W^{(i)^2} V^{(i)^2}}}{V^{(1)}} \qquad (2)$$

V.T index is an alternative index which incorporates the information, and in defined below. [5]Wi's are the TIF weights and (V(i)) are the ith harmonic components of line- to- line voltage V.

$$I.T = \sqrt{\sum_{i=2}^{1=\infty} W^{(i)^2} I^{(i)^2}}$$

$$V.T = \sqrt{\sum_{i=2}^{1=\infty} W^{(i)^2} V^{(i)^2}} \qquad (3)$$

$$K.V.T = 1000^{*}\, V.T \qquad (4)$$

Similarly I.T is a measure for line currents

$$DIN = \frac{THD}{\sqrt{1 + THD^{2}}} \qquad (5)$$

Observe that TIFV. Vrms = V.T

TIFI. Iyms = I.T.

***4** Distortion Index [DIN]*

5 C - Message weights [c] : The c- message weighted index for current i(t).

$$DIN = \frac{\sqrt{\sum_{i=2}^{1=\infty} V^{(i)^2}}}{\sqrt{\sum_{i=1}^{1=\infty} V^{(i)^2}}} \qquad (6)$$

$$C = \sqrt{\frac{\sum_{i=1}^{i=\infty} (C_i I_i)^2}{\sum_{i=1}^{i=\infty} (I_i)^2}} = \sqrt{\frac{\sum_{i=1}^{i=\infty} (C_i I_i)^2}{I^2_{r.m.s}}} \qquad (7)$$

6 Flicker Factor (F)

Vm cos(wf t) may be considered as being modulated by the signal Vf cos(w0t) where Vf is the flicker amplitude. Thus flicker component of bus voltage in

$$Vf\,(t) = Vf \cos(wf\,t).\ Vm \cos(w0\,t) \qquad (8)$$

And the total bus voltage is

$$V\,(t) = Vm \operatorname{Cos}(w0\,t) + Vf\,(t) = (1 + Vf \cos(wf\,t))\, Vm \cos(w0\,t). \qquad (9)$$

The $F = Vf/Vm.$ (10)

II. Power Quality Solution

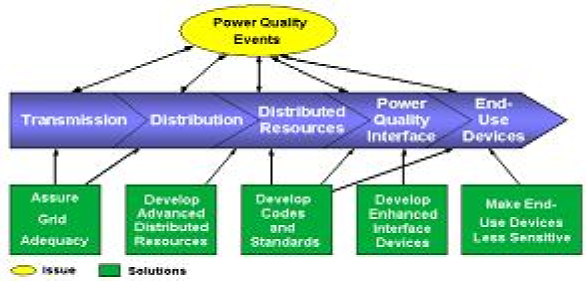

Fig-3- Steps for power quality solutions

A. Grounding & Bonding Integrity

Computer based industrial system performance is directly related to the quality of the equipment grounding and bonding. If the grounding and bonding is incorrectly configured, poor system performance is the result.[6] Grounding is one of the most important and misunderstood aspects of the electrical system. It is essential to differentiate the functions of the grounded conductor (neutral) from the equipment grounding system (safety ground).

B. Proper Wiring

An overall equipment inspection is crucial to ensure proper wiring within a facility.[7] The entire electrical system should be checked for loose, missing or improper connections at panels, receptacles and equipment. Article 300 of the National Electrical Code cover wiring methods and should be followed to ensure safe and reliable operation.

C. Restoring technologies

Restoring technologies are used to provide the electric loads with ride through capability in poor PQ environment.[8]

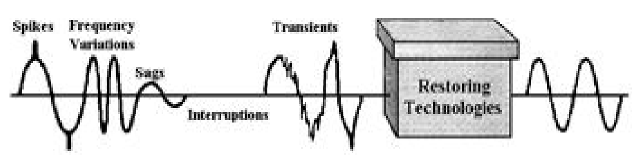

Fig-4 Restoring Technologies

D. Distributed Generation

Distributed Generation (DG) units can be used to provide clean power to critical loads, isolating them from disturbances with origin in the grid.[9] DG units can also be used as backup generators to assure energy supply to critical loads during sustained outages. Additionally DG units can be used for load management purposed to decrease the peak demand.

E. Enhanced Interface Devices

Besides energy storage systems and DG, some other devices may be used to solve PQ problems.[10] Using proper

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interface devices, one can isolate the loads from disturbances deriving from the grid.

1. Voltage compensator

Shunt voltage compensator Series voltage compensator

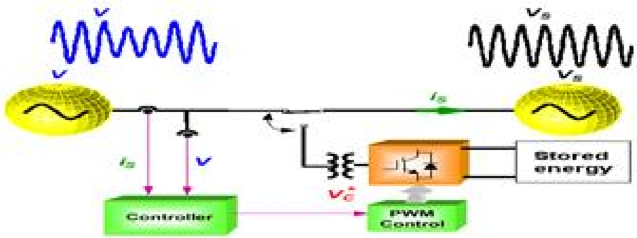

Fig-5 Voltage Compensator

F. End-use Devices Less Sensitive

• Some measures to increase equipment immunity:
– Add a capacitor with larger capacity to power supplies;
– Use cables with larger neutral conductors;
– Derate transformers;
– Use of oversized active front-ends.

Conclusion

Electric power quality, which is a current interest to several power utilities all over the world, is often severely affected by harmonics and transient disturbances. Due to increased use of various power electronic devices in modern power systems, power quality is becoming an important and challenging issue for the power engineers. There is no unique model which can assess the power quality problem and to identify and classify them properly.

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DOI: 01.IJRTET.8.2.541